The Pangea proposal for international or regional disposal facilities

Charles McCombie
CEO, Pangea Resources International
Ralph Stoll
Vice-President, Pangea Resources International

Abstract

In this paper, the arguments for international or regional radioactive waste disposal projects are first presented in a generic manner. Properly planned, constructed and operated repositories can bring benefits in safety, security, environmental protection and economics to both the host country and the customers. Thereafter, the particular attributes of the Pangea concept are pointed out. The solid technical basis underlying the choice of candidate host countries is summarised and then the project scope and current status are reviewed.

Introduction

This paper is based heavily upon the major presentation of the Pangea Project at the ICEM Conference in Nagoya in late 1999. Since then, concepts for international disposal of radioactive materials have continued to be the subject of intensive discussions in the waste management community. At the subsequent TOPSEAL Conference in Antwerp, the DOE Conference in Denver and again at the US National Academies Workshop in Irvine, lively debates on the topic took place. A special round table discussion is also scheduled for the IAEA Safety Conference in Cordoba in March 2000. The focus of the current meeting is regional rather than global, but the ethical, technical and economic arguments for common disposal facilities which serve a number of nations are the same. Within the IAEA, there has long been recognition that regional facilities could benefit member states with limited nuclear programmes, restricted resources or complex siting problems. Pangea has proposed various regions of the world as being particularly promising prospects for repository siting. These could serve a global need or could, with reduced requirements for spent fuel transports, act as hosts for regional facilities.

Since the Pangea concept was first publicised, discussions and presentations in international technical and political forums have made clear that there is a widespread appreciation of the advantages and the challenges of shared nuclear waste disposal, both global and regional. The timing is ripe to have an open discussion on the issue. The enthusiasm voiced by a large segment of the waste management community by no means implies that the proponents are blind to the major political obstacles to international solutions. Rather, it is a reflection of:

(a) years of built–up frustration at the slowness of progress towards implementing repositories - with the many delays being determined largely by political and social dissent
(b) an increased awareness that internationally supervised repositories accepting materials from weapons dismantling could be a key element in controlling the spreading threat of nuclear weapons proliferation
(c) a growing concern that larger, more affluent countries might establish a precedent or "ethic" that national solutions are a necessity. This could make nuclear power a non-viable alternative for smaller countries and hence a lesser contributor to a cleaner environment.

An opportunity to fulfil our ethical responsibilities to future generations by preparing proper disposal facilities in a co-operative effort between a willing, well suited host nation and a number of customer countries, under arrangements recognised as being fair to all, would be certainly welcomed by the

technical community. Also in the wider circle of stakeholders, including the general public and the political leadership, there is a broad appreciation of the technical benefits - and of the sociological challenges – resulting from international or regional waste disposition solutions.

Although many individuals do consider the time to be ripe for international initiatives, there are obviously also other schools of thought. From some national programmes, there is understandable apprehension that increasing attention on international options may lead to questioning of the need for (or the timing of) national repositories. In particular, national disposal programmes near to implementation of facilities are concerned about any distractions from this path and would prefer to complete their tasks without additional complicating issues being raised. Should we wait with international proposals until some national repositories are operating? There may be some truth in the opinion that international or regional disposal may become more acceptable once this is the case. The counter-arguments are that numerous programmes may have (or have already had) problems establishing a national geologic repository, for financial, sociological or technical reasons. It may even be that a globally or regionally optimised choice could be easier to implement and thereby contribute to progress and acceptance in national programmes as well. In any event, for environmental, safety and security reasons, acceptable solutions to the disposal of unwanted nuclear materials must be welcomed by all, and every serious effort to achieve these solutions deserves support.

Resistance to international repository concepts is to be expected from nuclear critics who oppose any promising solution for waste disposal. Equally expected, but less understandable, is the resistance in some quarters, based on the fear that less effort – or lower funding – will then be devoted to national programmes which are often coming under financial pressures for other reasons. However, solving problems using global or regional optimisation must be preferable to postponing responsibilities or to squandering of resources by duplication of technical work.

The goal is geologic disposal; extended storage is necessary but not sufficient

Storage of spent fuel or high level wastes for long periods of up to hundreds of years is a topical issue. Storage of this sort is attractive to many because it retains easy retrievability and avoids contentious decision-making in the short term. Storage is a proven technology and can be carried out safely almost anywhere, on or below the ground surface. There have been various proposals for international storage of spent fuel, often aimed at circumventing the sociological problems associated with national siting - problems which arise despite the demonstrable safety record of wet and dry storage facilities. Spent fuel and high-level wastes will certainly be stored for long times:

- because decades are needed for decay of heat generation,
- because there will be insufficient disposal facilities available for many years, and
- possibly because societal decision processes will also require decades.

The Pangea concept presented here, however, goes beyond storage. Storage merely postpones the task of developing a real solution for removing radioactive wastes from the human environment; it also leaves an open-ended risk due to the possibility of direct inadvertent or deliberate intrusion by humans. Pangea aims at ultimate disposal, i.e. at permanent isolation of the wastes. The concept is based on a deep geologic repository. Today, repositories of this sort are recognised as having two roles in the management of unwanted nuclear materials. These are:

- to dispose of long-lived radioactive wastes in a manner which will ensure the **safety** of all future generations, without placing on them any burden of active maintenance measures.
- to enhance world **security** by minimising the threat posed by the potential misuse of plutonium and enriched uranium derived from dismantling of surplus weapons in an age of nuclear disarmament.

The advantages of international or regional repositories

What advantages do international or regional repositories offer relative to national disposal projects in these two key areas?

In the area of safety, in particular long-term, post-closure safety, the difference between a multinational repository and a national project is not that a higher **level** of safety is aimed at in the former case. There is no need to tighten the rigorous safety requirements set for national disposal facilities and it is definitely not ethical to seek regions or countries where less stringent safety measures could be acceptable. In both cases, the repository should provide demonstrable safety by means of a robust barrier system, based on both engineered containment and also geological retention of radionuclides.

There are, nevertheless, certain technical issues which affect the choice of disposal concepts at any location. Most obvious is the question of the availability of suitable geologic formations. Repository designs are flexible and requirements on the geology can often be relaxed by increasing the sophistication of the engineered barriers. Thus, most countries should be able to find suitable sites. The key advantage of a global or regional choice of geologic environments concerns not the absolute level of safety, but rather the **confidence** with which we can predict the future safety. The problem of reliable prediction of future repository behaviour can be eased by adopting this straightforward approach - the long term containment of waste materials will be easier to achieve and to demonstrate in a simple, stable geological environment chosen from global or regional rather than national considerations without the restrictions imposed by political boundaries.

The previous point emphasises the issue of long-term safety, but concerns about operational safety are also of obvious relevance – in particular to the host State for an international repository. The specific operational safety issue most often raised by opponents concerns the incremental risks arising from the increased transport requirements when all wastes in a region are moved to a centralised repository. However, practical experience to date indicates that radiological risks arising from radioactive waste shipments are extremely low and are not determining factors in any disposal strategy. Similarly, the costs of transporting the restricted volumes of spent fuel or high-level wastes arising in the fuel cycle are not limiting factors (provided, of course, that orchestrated opposition, as has happened, for example, in Germany does not necessitate extreme measures). For voluminous low-level wastes, on the other hand, repositories near the waste sources are economically attractive.

In summary, well chosen international or regional repositories have no safety drawbacks and can have advantages, in particular concerning the ease of demonstrating the safety case.

A further key challenge which is most certainly of global interest in connection with disposal of nuclear materials and which can be more effectively met by an international repository is that of **safeguarding** these materials against misuse by terrorists or by rogue governments. Current estimates are that Russian and American plans for reducing nuclear weapon arsenals could lead to a surplus of around 2000 tonnes of highly enriched uranium (HEU) and over 200 tonnes of weapons grade plutonium. There are simple options for dealing with these weapon-grade materials. The plutonium can be fabricated into mixed oxide fuel (MOX) which is then burned in reactors, producing highly radioactive spent fuel which is much more proliferation-resistant. Alternatively it can be conditioned into a suitable form for disposal, e.g. by incorporation into a SYNROC type of matrix. The HEU can be blended down to produce normal low enriched fuel for the current generation of reactors. Again the result is spent fuel which is more proliferation resistant but still requires safeguards measures. Thus, a deep geologic repository provides a proper end point for each option. An international repository in a country acceptable to all nuclear weapon States could facilitate the process of obtaining the necessary political agreements to further reduce the number of nuclear weapons. It could also contribute to the release of the inherent economic value of these excess materials, especially important to Russia, and

provide a commercial source of financing to address non-proliferation goals which are currently difficult for governments to fund.

Furthermore, the safeguarding of nuclear materials derived from disarmament programmes at an international repository would be easier, more transparent and highly amenable to international oversight by the IAEA and by any other States. This improved safeguards regime is equally important for spent fuel from commercial nuclear power production. Obviously, major nuclear nations can, and do, adequately safeguard their spent fuel, but numerous small repositories spread around the world would clearly be more difficult to monitor effectively. In fact, given a global choice of repository location, it would also be feasible to choose a site with particularly favourable characteristics from a safeguards and monitoring viewpoint (e.g. remote with easy satellite monitoring).

An international repository of this type can engender trust not only in the disarming nuclear weapon States and in the host and customer countries of a commercial disposal operation, but also in all of the world's nuclear nations. If a respected nation - with suitable geologic conditions and with environmental and non-proliferation credentials able to withstand the scrutiny of the world - were willing to accept such materials, it could thus give an added impetus to the disarmament programmes of the major nuclear weapon States and could improve safeguards on conventional spent fuel. The result is a win-win situation. In fact, this could even be labelled a win-win-win situation since the international repository is then of direct benefit not only to the host and the customer but also to the present and future citizens of all nations interested in encouraging peace in the world.

Benefits go beyond safety and security issues

An international repository can bring advantages beyond the direct safety and security areas mentioned, advantages which benefit both host and customer countries. These include bringing economic benefits, minimising global environmental impacts and enhancing public acceptance of disposal. These points are briefly explained below.

Economic benefits:

Shared repositories are certainly attractive from an economic point of view. Deep geologic repositories have life-cycle costs in the billions of US dollars. This is true even for small countries with low projected waste volumes; for example, the Swiss estimate of life-cycle costs for disposing of HLW or spent fuel from a 120 GW(e).y nuclear programme is around 3 billion US dollars. Moreover, large parts of the cost of any deep repository are fixed, i.e. they are independent of the inventory since they are needed for exploration, for gaining access to the underground by shaft sinking, for installation of infrastructure, and for the complex permitting and licensing procedures. The marginal costs of excavating more disposal volume underground are relatively small. Accordingly, large savings are possible if small countries combine their efforts in a regional manner or if a large disposal programme were to accept wastes from foreign sources.

For a country accepting foreign wastes for disposal, there clearly could be enormous direct economic benefits. For countries paying for disposal of wastes abroad there could also be financial advantages because economies of scale allow lower unit costs (and excellent geological conditions can obviate the need for very expensive engineered barriers). For society in general, it is certainly better to channel resources to other causes rather than expending them on duplication of expensive technical and geological work in numerous countries.

Public acceptability and ethical arguments

Why should a country agree to host an international repository? Only if the safety and security aspects are clearly seen to be taken extremely seriously by all parties and if the economic and infrastructure

benefits are very clear, is it conceivable that public acceptance in a host country can be achieved. A serious host country will not allow itself to be "bought"; there must be also a clear perception that the host is undertaking a service which helps less advantaged countries fulfil their moral responsibilities for their waste in an ethical manner. A serious customer nation will insist on being assured that the appropriate high standards of safety and environmental protection are applied to any facility accepting its waste. If these two conditions are fulfilled, it becomes plausible that overall public acceptance of geologic disposal could be higher than in the present controversial situation.

The ethical issues associated with waste disposal have been discussed at length in recent times. The principles espoused by the waste management community concerning intragenerational and intergenerational equity have been formulated. These involve protection of all persons and of the environment now and in the future, irrespective of national boundaries. Clearly an international repository must and could be implemented in accord with such principles. The level of safety required for populations around any repository cannot be a function of the country, region or community in which the facility is located. The aspect of disposal of unwanted materials from disarmament raises a new and powerful ethical argument. A responsible, secure host nation which accepted the responsibility for the guardianship of materials which might otherwise cause mass destruction anywhere in the world would definitely be on high moral ground. An improvement in global security benefits all peoples now and in the future.

Minimising global environmental impacts

Environmental protection can become easier for all parties with a world-wide choice for a disposal site. On a global scale, the extensive use of nuclear power in, for example, East Asia contributes to limiting carbon dioxide emissions. This can continue, however, only if feasible and cost-effective disposal solutions are found even for countries which themselves have complex geology which makes siting a national facility difficult. An international repository can contribute here. At a national scale, small, crowded countries or geologically complex countries with limited siting choices also have a difficult problem in implementing any new and large industrial project while minimising impacts on the human environment. In a host country with remote areas far from the public, siting may be less contentious. Indeed, there is a definite potential for using a well-funded repository implementation project as a vehicle for improving facilities and conditions in inhospitable areas.

Nevertheless, a major international or regional repository, with its necessary transport and site infrastructure, will obviously have a significant environmental impact, comparable perhaps to a mining project. To compensate for this asymmetric burdening of host and customer, appropriate benefits justifiably may be expected by the host. These may go beyond the obvious financial arrangements to include wider agreements in the areas of trade, politics or diplomacy. Again, the objective is to ensure a win-win situation, with potential advantages for both host and customer country.

International solutions are not without problems

Not withstanding indisputably positive arguments, public acceptance for disposal of foreign wastes will be difficult to achieve in any potential host country. The public view is conditioned everywhere by fear of radioactivity. It is of little importance whether this fear is rational or not; the results are the same. Persistent and open dialogue based on high-quality work throughout the waste management community can help build the necessary level of public trust. But NIMBY (not-in-my-backyard), which functions so universally on a national scale, will certainly be a problem also internationally. There is a general aversion to waste disposal facilities (although this paradoxically does not prevent routine transboundary shipments of chemotoxic wastes for disposal), and the situation is especially difficult for radioactive wastes. The localised environmental impact of any large project, which serves the good of a wider public, will almost always create localised opposition. There are various ways to counteract this, the most powerful being close consultation and contact with the host community and

allocation of appropriate economic benefits. Both issues are obviously of relevance also for international repositories.

The issues of perceived repository safety, economic benefits and ethical behaviour are closely interrelated. If a sufficiently broad consensus existed that hosting a repository was comparable to hosting any other major, long-term industrial project — with the usual trade-off of economic, social and environmental considerations — then there would be no ethical dilemma in exporting or importing wastes for disposal. Compensation would be based upon judgements of the value of a localised community performing a service for the common good and on the fair allocation of resources needed to develop the social infrastructure associated with the arrival of a major project. There might even be competition, as has been the case for various joint international research facilities, to host a repository.

The origins of the Pangea Project

Pangea is a privately funded project which is not yet specifically endorsed by any national government. The company is currently engaged in feasibility studies only and is seeking the opportunity to engage governments and their experts in a reasoned, objective dialogue about our vision of the benefits of an international repository for final disposal of long lived radionuclides. Pangea is also working to stimulate an open discussion with the public and all groups which take a direct interest in our proposal.

There are good reasons for launching a new initiative at this particular time. In recent years, geologic disposal planning world-wide has experienced setbacks. Despite the diligent efforts of scientists, engineers and government policy makers, many national programs are suffering delays, cost overruns, and, in some unfortunate cases, significant loss of investment due to failed attempts to site a geological repository. The unexpected complexity of making a safety case in highly heterogeneous geologic media has been one of the key factors contributing to these problems. At Pangea, we believed that both scientific and public confidence in the safety of disposal concepts would be enhanced if these were based, as far as possible, on simple and robust geologic systems.

A further aspect of great importance at Pangea was the recognition that, with the end of the Cold War, an enormous effort will be required to properly manage the safe and secure disposition of excess nuclear weapon materials as the world progresses towards nuclear disarmament. Since the vast majority of weapon-grade materials are likely to be converted to fuel for light water reactors, an international repository for the resulting spent fuel would certainly expand the range of options and economic incentives for nuclear weapon States

Accordingly, Pangea was developed with a strong focus on the long-term safety of repositories and on the security of weapon-derived materials. The former aspect led to the definition of the "high-isolation" concept for repositories which is defined in the following section. It has as its core a geologic repository located in suitable, very simple and stable geology, with flat topography in a stable arid climate whose evolution can be predicted with relative ease. To address the latter, equally important issue of international security, we need to concentrate on potential host countries which will strongly support non-proliferation efforts and which are trusted by the other nations of the world.

The original organisations developing the project (BNFL, EHL and Nagra) together brought to the enterprise the necessary skills for the conceptual planning and the scientific and technical studies. Currently, the companies, Pangea Resources International and Pangea Resources Australia, are owned by BNFL and EHL, with additional partners being actively sought.

The high-isolation site concept

The basic feasibility of geologic disposal is accepted within the waste management community and innumerable panels of international experts have asserted that safe disposal can be achieved. In almost all states with nuclear activities, programs for repository development are underway and no insuperable technical problems are foreseen by those directly responsible, or indeed by the majority of the scientific/technical community. In wider public and political circles, however, perceptions are often different. Waste disposal programs are **not** widely regarded as being on a straightforward – if slow – route towards successful implementation. Rather the process is often seen as fragile, faltering or even failed. In recent years there has, therefore, been growing support for other approaches such as long-term surface storage or advanced transmutation schemes – although neither of these can be regarded as a real alternative to deep geologic disposal.

The single most important reason for this is the lack of public confidence in the ability of scientists to predict repository performance with sufficient reliability over the long time scales of relevance. Methodologies have been developed by the experts to at least scope the bounding behavior of disposal systems. However, safety assessments for deep repositories have become extremely complex (and hence non-transparent to many) and they are dependent on assembling huge databases which are expensive, difficult to quality-assure and still open to criticism for their potential omissions or errors. Within the technical area, the issue which has undoubtedly led to the most debate is the characterization of the deep geologic environment at a potential repository site. Because the geologic media being studied are mostly complex and heterogeneous on the scales of relevance, this has turned out to be a much more challenging task than was appreciated in early years.

Pangea, using the knowledge and experience gathered over decades of study in numerous programmes on repository safety, asked a different question. If one were unrestricted by national boundaries, how would one go about choosing a repository site which would be not only extremely safe but also as simple as possible, in order that the safety case could be demonstrated with the most transparency - for the public as well as for the experts? A set of attributes for such a site was developed, based on consideration of the features, processes and events taken into account in state-of-the-art safety analyses of repositories. These characteristics can be summarised thus:

- Stable geology (needed because of the long isolation times aimed at)
- Flat topography (reduces driving forces for groundwater movement)
- Near-horizontal sedimentary strata (simpler to explore and extrapolate)
- Stable, arid climate with little erosion (eases problem of extrapolation into the future)
- Low permeability host rock (reduces groundwater movements)
- Old and saline groundwater (indicates groundwater movement; non-potable)
- Stratified salinity (counteracts thermal buoyancy effects)
- Reducing geochemical conditions (reduces solubilities of radionuclides)
- Absence of complex karst systems (simplifies hydrogeologic modeling)
- Low population density (reduces intrusion risks)
- No significant resource conflicts (reduces intrusion risks)

Obviously, sites need not fulfil **all** of these criteria to be suitable and some are clearly of greater importance than others. Furthermore, even in a global search for promising sites, one can not focus only on technical criteria. Societal decision making will also be involved; it may well be necessary to compromise on some of the above criteria to arrive at practicable solutions. This is justifiable as long as overall safety can still be convincingly demonstrated. In principle, the safety assessment for a high-isolation site satisfying the above constraints will not differ from safety assessments as produced in other repository programs. In practice, the high isolation siting concept is aimed at easing the burden of demonstrating safety by choosing a system with as many positive safety characteristics as is feasible. The objective is to choose a site and design that are of intrinsic high quality with respect to safety and are also amenable to a reliable assessment of safety.

In detail, the safety case for a high-isolation site may be different from that for more conventional sites because of the low energy natural system, which has extremely low driving forces for any processes which could lead to radionuclide release and transport. This should make it easier to deal with groundwater flow scenarios of the types that are central to most conventional safety assessments. Directly demonstrating extremely long residence times (e.g. by age dating, salinity profiling) will be an important goal. Because of the expected near stationary groundwaters, however, the safety case may have to focus more upon potential disturbances of the natural system due to artifacts introduced by the repository itself.

A study of the world aimed at identifying large, flat, historically-arid areas with stable and simple geologic formations quickly leads to a group of areas which were part of the original Pangea supercontinent which started to break apart some 200 million years ago. Remaining in the continents of the Southern Hemisphere as they drifted apart are areas which have been subjected neither to large tectonic forces nor to the influences of repeated glaciation. The largest contiguous stretch is in the desert basins of Western and South Australia and other potential high-isolation site regions have been identified in Argentina, Southern Africa, and China. The intention is to carry out in-depth feasibility studies for the various potential host regions and, as described below, the pilot studies in Australia are currently in progress.

The Pangea system and its economic impact

The total waste management and disposal system foreseen by Pangea includes packaging and national transport of spent fuel or wastes (if required by the customer country), international transport in a fleet of dedicated ships, rail transport to the repository site, buffer storage and final disposal. The reference concept is for disposing of an inventory corresponding to around 75,000 tonnes of spent fuel over 40 years of operation, although there are no fundamental reasons for either limit. At the current feasibility analysis stage, designs are at the conceptual level and costs are partly by analogy with existing and planned facilities elsewhere.

Broad estimates, however, give the following picture. The construction costs of the ships, sea terminal, rail link and repository will be in the order of US$ 6 billion. Half of this cost is attributable to the sub-surface facilities at the repository, which will be progressively developed over the 40 years operational life of the repository. The annual costs associated with the operation of the repository, together with the transport and handling of the cargo from the waste generators to the repository will be in the order of US$ 0.5 billion.

In the above-mentioned pilot study in Australia, it was estimated that several thousands of jobs would be created during the construction of the sea terminal, rail link and repository. Further employment opportunities exist in the manufacture of transport casks and ships. The operation of the facilities is likely to provide long-term employment for more than 1500 people. Many of the positions created will be in areas of high technology, engineering and science. In addition, there will be employment in necessary service industry branches. Finally, the economic boost of the project to the host nation will provide further opportunities for employment.

Political and public issues

Good science and sound economics are, by themselves, not enough to make international disposal a reality. Political and public acceptance is needed. The host state for a successful international repository must have political credibility and must be an equal, willing partner of user countries There must be continuing international trust in the political system of the host country. No nation should pass its waste to others unless it is convinced that this is a responsible action, based on mutual agreement between partners. A responsible co-operation will weigh up all aspects of safety, security, sustainability, economics and geopolitical considerations. Transfer of waste should bring advantages to both customer and host nations and, ideally, also for the global environment. There are many

nations in the world (small countries with limited nuclear power programs or large countries in economic disarray) where establishing the economic base to build a safe and permanent disposal facility would be challenging – or even impossible. Also in some countries the geology, or the surface environmental conditions, or the density of population can present major obstacles to the construction of a deep geologic repository.

The above considerations lead to the conclusion that international repositories, whether global or regional in scope, would be of mutual benefit to the hosts and to the customer countries. We fully recognise that some nations will wish to proceed with national solutions, but we are convinced that a number of shared facilities must also be implemented in the future. We realise there are those who today will wish to oppose any international solution because it is feared this will remove an important obstacle to further expansion of commercial nuclear power generation. The goals of Pangea, however, are sufficiently justified alone by the need to deal with waste from existing commercial reactors and from the dismantling of nuclear weapon programs. These are compelling arguments for providing the option of an international or regional repository. The key issues concern safety, environmental impact, security and ethics.

Pangea believes that the most important mission of achieving political and public acceptance will require us to demonstrate the moral and ethical values of the enterprise. Good science, backing a robust safety case, is an absolute prerequisite for achieving acceptance of any disposal project. Economic benefits will, of course, also play an important role in convincing the public and the governing officials of any potential host country to accept an international repository. But this is not enough. In addition, there must be an acceptance on the part of the international community of the ethical, political and technical correctness of the Pangea solution for those nations which choose to make use of it, and equally there must be recognition and acceptance by the host country that it is willingly providing a valuable service contributing to the world's environmental safety and security.

Pangea's Current Status

Pangea is an international venture. It is to be expected that, for the following reasons, there will be more than one international repository needed in the world:

- countries will prefer not to be the sole site for shared facilities
- regional concentration of activities could help optimise transport aspects of international disposal
- competition in a business sense may well arise once a first project is established
- for ensuring stability, customer nations may well prefer to have diverse providers of disposal services for their spent fuel or high-level wastes
- similarly, for disposal of materials derived from weapons dismantling, more than one option would be preferable.

Limited available resources necessitated focussing for Pangea's pilot feasibility studies on one initial option and Australia was the choice. The prime reasons for setting priorities in this way were the large size of the Australian candidate regions and also the established positive reputation of Australia in the environmental and non-proliferation areas. Technical studies on the relevant desert basin areas in Australia are still in progress and there has been a very active public debate to date. There are strong supporters (particularly in the academic and business communities) who advocate that Australia must seriously evaluate the pros and cons of the Pangea proposal. In particular, a rigorous, objective and open review of all Pangea work will be undertaken by an independent Scientific Review Group with credentials second to none in the world.

Nevertheless, there has been little political support in Australia. This is partly due to the premature release by environmental organisations of project data obtained through unofficial channels. This information had been prepared by Pangea with the intent of providing comprehensive information to start the public debate simultaneously to politicians, officials and the public. The initial reactions of

some political leaders not yet briefed on the project were understandably negative. In Western Australia, which has been the main focus of the geological feasibility studies, legislation has been passed prohibiting disposal of foreign wastes. This can be changed only by explicit consent of both houses of Parliament. This does not prevent Pangea completing the studies and putting its case to the public and the decision-makers, and this is the course Pangea Resources Australia (PRA) will follow over the next 1-2 years.

Meanwhile, the parent company, Pangea Resources International (PRI), is working to establish more firmly the concept of international disposal. This is being done mainly by engaging the international community in debate at major conferences and through bilateral discussions with interested parties. In addition, technical planning is being advanced, geological feasibility studies are being initiated in the other world regions already judged most promising, and the completeness of the original world screening is being reviewed. Among the initial Pangea partners, Nagra has elected not to hold equity in PRI, in order to avoid perceived conflicts with its national siting programme – although Switzerland retains its dual track policy of considering for the future both national and international HLW disposal options. Further partners in PRI are being actively sought and efforts are underway to co-ordinate the interests of small countries which are dependent on international solutions becoming a reality. The activities of Pangea to date have led to a welcome opening of the discussion on international repositories. The potential positive impulse which the existence of such facilities could give to the faltering efforts to accelerate the pace of weapons dismantling is a powerful argument for governments and individuals with security concerns.

In conclusion, the following key points can be drawn:

- The time is ripe for widening the discussion on the value and role of international repositories.
- There are growing needs in small countries for economically viable disposal options for their commercial wastes.
- There is growing appreciation of the potential contribution of international repositories to encouraging further disarmament efforts.
- There is understandable sensitivity in national programmes concerning possible negative impacts on their own disposal programmes. However, every nation can choose a national solution if it so prefers and no nation can be compelled to accept waste from others if it does not wish to.
- A fair partnership between willing hosts and customers of international or regional repositories can be of benefit to all.
- Pangea has proposed a technical approach founded on optimising key factors in the safety case – this is not primarily an issue of safety levels, but rather of higher confidence in the safety case.
- The economics of Pangea's proposals show clearly that there can be benefits for all participants.
- The political and societal issues are, for international as for national projects, the most challenging.
- Pangea is engaging in pilot feasibility studies covering all three aspects (safety, economics and society) in various regions of the world, chosen primarily for scientific reasons.
- As was to be expected, the successes have been largely technical and the setbacks largely political.
- Positive further progress can be achieved only by Pangea maintaining a transparent, high-quality programme.
- Pangea must take into account to the greatest extent possible the concerns of all stakeholders in potential host countries, in potential customer countries, and also in other nations which choose to go their own way in solving the long standing problem of implementing safe, acceptable repositories for long lived radioactive wastes.